

Summary of a Possible Cleanup Strategy

Open Salvage/Storage Yard (Area of Concern 2) Bainbridge Naval Training Center Port Deposit, Maryland

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Background

The U.S. Fish and Wildlife Service, Chesapeake Bay Field Office (CBFO) is assisting the U.S. Navy in the evaluation of remediation options for the Former Open Salvage/Storage Yard (Area of Concern 2) at the Bainbridge Naval Training Center. The storage yard is an approximately 12,000-ft² rectangle, bounded on two sides by block wall receptacles approximately 4 ft high. Coal ash/cinders were used as a paving material at the site where scrap metal was stored. Soil samples were collected and analyzed for metals and polycyclic aromatic hydrocarbons (PAHs). Maps of the site and sampling locations can be found in EA Engineering, Science and Technology (1997). The purpose of this presentation is to facilitate the selection of an appropriate cleanup strategy.

Methods

Chemical data from two rounds of sampling were provided to CBFO and a spreadsheet is attached (Table 1). The first step in the process is to screen the maximum soil concentrations against the EPA Region III Biological Technical Assistance Group (BTAG) screening levels. The division of a concentration (or estimated exposure) by a toxicological reference value (or screening level) results in a hazard quotient (HQ).

As shown in Table 2, there are exceedances of the screening levels for multiple PAHs and metals. HQ values greater than one suggest the potential for ecological risk. The compounds with the highest values, HQs > 100, were acenaphthene, phenanthrene, fluoranthene, pyrene, aluminum, antimony, beryllium, chromium, iron, lead, mercury, silver, thallium, vanadium and zinc (Table 2).

The habitat in the Open Salvage/Storage Yard is of relatively high quality, to the extent that it is

overgrown with shrubs and small trees. As such, the need for cleanup should be balanced against the habitat destruction that would result. For the protection of human health, the recommendation has been made to remove soil hotspots within the Open Salvage/Storage Yard, specifically sites 2-SS-4, 2-SS-6, and 2-SS-7. Here we present HQ calculations if a similar approach (i.e., removal of soil hotspots) was used to reduce risk to ecological receptors. Tables 3 and 4 indicate the HQs which would result if soil in the vicinity of stations 2-SS-4, 2-SS-6, 2-SS-7, 2-SS-14 and 2-SS-15 was removed. By focusing on the selective removal of hotspots rather than excavation of the entire area, it may be possible to reduce the ecological risk associated with exposure to soil contaminants to an acceptable level without causing total destruction of the existing high quality habitat.

To be conservative, the BTAG Region III soil screening benchmarks are based on the lowest toxicological effect levels reported in the literature. Other soil benchmarks that are commonly used in ecological risk assessments include values published by the Canadian Council of Ministers of the Environment (CCME 1997) and the Oak Ridge National Laboratory (ORNL, Efroymson et al. 1997). In general, these values are less conservative than the BTAG numbers because they are based on a preponderance of evidence, not the lowest possible value. For purposes of comparison and discussion, Table 4 also presents HQs calculated using these benchmarks. For several compounds, the ORNL has developed benchmarks for both soil invertebrates and microbes. The lower of these two values was included in the HQ calculation.

Results

Removing stations 2-SS-4, 2-SS-6, 2-SS-7, 2-SS-14 and 2-SS-15 from the hazard calculations dramatically reduces the HQs for most compounds, suggesting that a large reduction in ecological risk would result from selective cleanup of soil hotspots (Table 4). However, HQs for many compounds are still greater than one when compared to BTAG screening values. As expected, application of the less conservative CCME and ORNL benchmark values serves to further reduce the HQs, many to values less than one. For comparative purposes, HQs were also calculated for the mean soil concentrations. It is hoped that these comparisons will provide a framework for a discussion of the cleanup strategy at the Salvage yard. Hence, these calculations and charts should be provided to the EPA Remedial Project Manager and the BTAG. A meeting to discuss the cleanup strategy should be scheduled.

References

Canadian Council of Ministers of the Environment. 1997. Recommended Canadian Soil Quality Guidelines.

EA Engineering, Science and Technology. 1997. Environmental Baseline Survey Task 2 Analytical Report Naval Training Center-Bainbridge.

Efroymson, R.A., M.E. Will, and G.W. Suter, II. 1997. Toxicological Benchmarks for Contaminants of Potential Concern for Effects on Soil and Litter Invertebrates and Heterotrophic Process: 1997 Revision. Prepared for the U.S. Department of Energy, Office of Environmental Management by Lockheed Martin Energy Systems, Inc., Oak Ridge National Laboratory.

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Spreadsheet with Soil Contaminant Data and Risk Calculations

AOC 2

Open Salvage/Storage Yard

Bainbridge Naval Training Center

Table 1. Open salvage/storage yard (AOC 2) soil data

Soil PAH and metals (AOC 2)	AOC 2	organics in ug/kg				metals in mg/kg														
Low Molecular Weight PAHs		2-SS-1	2-SS-2	2-SS-3	2-SS-4	2-SS-5A	2-SS-5B	2-SS-6	2-SS-7	2-SS-8	2-SS-9	2-SS-10	2-SS-11	2-SS-12	2-SS-13	2-SS-14	2-SS-15	Max	Mean	
2-methylnaphthalene		NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA			
Acenaphthene	125	105	175	2200	170	1200	79	19000	410	1700	1000	160	1000	590	3500	25000	25000	3525.9		
Acenaphthylene	240	200	345	4250	41	4250	41	42	130	43	39	40	42	41	43	40	4250	614.0		
Anthracene	25	21	36	740	10	770	3	2000	23	140	100	8	75	51	230	2700	2700	433.3		
Fluorene	24	20	34.5	425	4.1	235	4.2	800	4.1	56	37	4.0	13	23	45	1900	1900	226.8		
Naphthalene	125	105	180	2200	24	1200	24	320	23.5	370	70	23.0	74	91	340	1300	2200	404.3		
Phenanthrene	110	25	130	4200	41	3200	36	7100	110	790	380	61	290	250	1200	14000	14000	1995.2		
Total Low Molecule Weight PAHs																				
High Molecular Weight PAHs																				
Benzo(a)anthracene	120	30	76	1900	110	1600	20	5000	110	370	220	30	280	110	710	4800	5000	967.9		
Benzo(a)pyrene	200	70	190	2400	280	1800	30	4300	96	440	240	41	310	150	940	4300	4300	986.7		
Benzo(b)fluoranthene	620	66	190	1900	570	1800	45	5600	130	510	290	57	370	180	1200	5300	5600	1176.8		
Benzo(g,h,i)perylene	120	51	94	1200	1200	790	75	3300	170	320	180	40	210	110	770	3100	3300	733.1		
Benzo(k)fluoranthene	110	33	85	1300	240	1100	14	2500	46	220	120	21	150	78	500	2300	2500	551.1		
Chrysene	180	53	110	2600	120	1900	17	3800	85	210	180	32	180	86	630	3300	3800	842.7		
Dibenz(a,h)anthracene	24	20	34.5	425	100	235	4.6	450	14	42	32	4.8	32	16	93	370	450	118.6		
Fluoranthene	240	48	210	4500	110	3600	47	12000	200	1000	500	77	560	300	1900	14000	14000	2455.8		
Indeno(1,2,3-c,d)pyrene	83	38	130	960	670	750	40	1900	65	180	93	18	120	62	360	1800	1900	454.3		
Pyrene	220	43	150	3700	81	3100	36	8600	160	820	400	64	480	240	1400	10000	10000	1843.4		
Total High Molecular Weight PAHs																				
Total PAHs	2566	928	2170	34900	3771.1	27530	515.8	76711.5	1776.6	7210.5	3880.5	680.8	4186	2377.5	13861	94209.5	94210	17330		
Metals (mg/kg)																				
Aluminum	9370	6860	7340	5390	4050	8160	44400	57900	4200	2440	3950	4650	11400	4790	3430	2720	57900	11316		
Antimony	0.095	0.090	0.84	6.7	3.2	0.090	17.8	71	1.8	1	2	1.4	1.2	1.9	4.6	3.9	71	7.4		
Arsenic (total)	2.4	2.5	5.9	17.7	9.6	3.4	32.3	74	2.5	15.1	16.2	3.6	4.8	3.9	12.2	4.2	74	13.1		
Barium	37.5	21.4	66.7	175	99.6	50	759	514	53.9	87.6	64.7	76.6	53.4	46.2	125	65.3	759	143.5		
Beryllium	0.35	0.36	0.33	0.28	0.32	0.43	3.4	3	0.26	0.33	0.3	0.37	0.43	0.37	0.42	0.16	3.4	0.69		
Cadmium	0.13	0.12	0.19	13.3	2.4	0.12	8.1	10.9	0.31	0.52	1	0.35	2.4	6	16.1	6.5	16.1	4.3		
Calcium	46700	884	1830	9850	1270	31200	18900	10200	1210	3760	1040	706	1110	672	2970	1820	46700	8382.6		
Chromium (total)	12.9	13.7	11.4	36.1	15.4	12.6	114	148	8	5.5	11.6	11.9	19.7	12.2	22.9	18.6	148	29.7		
Cobalt	6.1	5.3	7.1	9	4.9	5.4	68.4	42.6	4.4	2	6.2	3.1	6.9	6.2	9.2	7	68.4	12.1		
Copper	6.9	11.8	38.7	203	37.1	12.6	309	197	17.9	4.6	242	24.5	14.1	42.1	118	61.9	309	83.8		
Iron	19000	11900	11100	45800	16600	14100	175000	117000	10500	5870	12100	12700	22500	10100	29200	11800	175000	32829		
Lead	8.7	27.9	74.9	903	181	52.1	3950	1150	54.6	60.8	133	67.1	44.5	136	545	550	3950	496.2		
Magnesium	3680	1680	735	4510	738	4250	5030	15400	523	566	468	445	1110	472	494	526	15400	2539.2		
Manganese	340	235	363	446	226	215	3710	879	253	53.7	307	180	152	151	1030	54.8	3710	537.2		
Mercury	0.05	0.02	0.44	7	0.4	0.05	0.29	4.1	0.030	0.21	0.16	0.22	0.19	2.9	1.5	0.57	7	1.1		
Nickel	10.3	8.8	20.5	80.6	11.7	9	104	118	5.1	9.5	6.2	7.2	11.2	20.6	26	12.3	118	28.8		
Potassium	413	830	445	640	212	750	2520	2700	234	183	211	104	371	171	300	149	2700	639.6		
Selenium	0.12	0.11	1.6	1.4	3.3	0.26	13	8.5	0.91	1.4	0.87	0.88	1.5	1.1	2.9	1.3	13	2.4		
Silver	0.23	0.21	1.5	0.9	0.06	0.22	0.60	2.8	0.055	0.060	0.050	0.055	0.060	0.055	0.49	0.055	2.8	0.46		
Sodium	37.7	21	57.3	113	98.4	60.9	869	836	92.6	159	77.5	89.8	98	106	147	90.4	869	184.6		
Thallium	0.18	0.17	0.27	0.35	0.46	0.46	0.60	0.55	0.055	0.060	0.055	0.055	0.24	0.055	0.060	0.050	0.60	0.23		
Vanadium	14.2	15.9	19.5	106	21.2	19.3	200	245	24.9	12.4	20.9	21.4	44.5	19	18	24	245	51.6		
Zinc	23.2	34.9	147	1430	286	43.9	1990	2760	105	180	158	59.8	149	450	2760	1190	2760	735.4		

Table 2. Open salvage/storage yard (AOC 2) vs. BTAG screen

			Soil (organics in ug/kg; metals in mg/kg)					
Contaminant	Soil	Number	Total	Benchmark	Reference	Hazard		
	Maximum of Concentration	Detections	Number of Samples	Source		Quotient		
Low Molecular Weight PAHs								
2-methylnaphthalene	NA			NB	NB			
Acenaphthene	25000	11	16	100	x - fauna	250		
Acenaphthylene	4250	1	16	100	x - fauna	42.5		
Anthracene	2700	15	16	100	x - fauna	27		
Fluorene	1900	7	16	100	x - fauna	19		
Naphthalene	1300	7	16	100	x - fauna	13		
Phenanthrene	14000	16	16	100	x - fauna	140		
Total Low Molecular Weight PAHs				NB	NB			
High Molecular Weight PAHs								
Benzo(a)anthracene	5000	16	16	100	x - fauna	50		
Benzo(a)pyrene	4300	16	16	100	x - fauna	43		
Benzo(b)fluoranthene	5600	16	16	100	x - fauna	56		
Benzo(g,h,i)perylene	3300	16	16	100	x - fauna	33		
Benzo(k)fluoranthene	2500	16	16	100	x - fauna	25		
Chrysene	3800	16	16	100	x - fauna	38		
Dibenz(a,h)anthracene	450	11	16	100	x - fauna	4.5		
Fluoranthene	14000	16	16	100	x - fauna	140		
Indeno(1,2,3-c,d)pyrene	1900	16	16	100	x - fauna	19		
Pyrene	10000	16	16	100	x - fauna	100		
Total High Molecular Weight PAHs								
Total PAHs	94210			NB	NB			
Metals (mg/kg)								
Aluminum	57900	16	16	1	x - flora	57900		
Antimony	71	13	16	0.48	x - flora	147.9		
Arsenic (total)	74	16	16	328	x - flora	0.2		
Barium	759	16	16	440	x - fauna	1.7		
Beryllium	3.4	16	16	0.02	x - flora	170		
Cadmium	16.1	12	16	2.5	x - flora	6.44		
Calcium	46700	16	16	NB	NB			
Chromium (total)	148	16	16	0.0075	x - fauna	19733		
Cobalt	68.4	16	16	100	x - flora	0.7		
Copper	309	16	16	15	x - flora	20.6		
Cyanide	NA			16	0.005	x - fauna		
Iron	175000	16	16	12	x - fauna	14583		
Lead	3950	16	16	0.01	x - fauna	395000		
Magnesium	15400	16	16	4400	x - fauna	3.5		
Manganese	3710	16	16	330	x - fauna	11.2		
Mercury	7	14	16	0.058	x - fauna	120.7		
Nickel	118	16	16	2	x - flora	59		
Potassium	2700	16	16	NB	NB			
Selenium	13	14	16	1.8	x - fauna	7.2		
Silver	2.8	4	16	0.0000098	x - flora	285714.29		
Sodium	869	16	16	NB	NB			
Thallium	0.6	3	16	0.001	x - flora	600		
Vanadium	245	16	16	0.5	x - flora	490		
Zinc	2760	16	16	10	x - flora	276		
NB = No benchmark								
NA = Not Applicable								
x-fauna= Region III BTAG Screening Level for fauna (the lowest of flora and fauna)								
x-flora= Region III BTAG Screening Level for flora (the lowest of flora and fauna)								

Table 3. Open salvage/storage yard (AOC 2) data with "hotspots" removed

raw data without hotspots: 2-SS-4, 6, 7, 14, and 15														
Soil PAH and metals (AOC 2)	AOC 2	organics in ug/kg		metals in mg/kg										
		2-SS-1	2-SS-2	2-SS-3	2-SS-5A	2-SS-5B	2-SS-8	2-SS-9	2-SS-10	2-SS-11	2-SS-12	2-SS-13	Max	Mean
Acenaphthene		125	105	175	170	1200	410	1700	1000	160	1000	590	1700	603.2
Acenaphthylene		240	200	345	41	4250	130	43	39	40	42	41	4250	491.8
Anthracene		25	21	36	10	770	23	140	100	8	75	51	770	114.5
Fluorene		24	20	34.5	4.1	235	4.1	56	37	4.0	13	23	235	41.3
Naphthalene		125	105	180	125	1200	23.5	370	70	23.0	74	91	1200	217.0
Phenanthrene		110	25	130	41	3200	110	790	380	61	290	250	3200	489.7
Total Low Molecular Weight PAHs														
High Molecular Weight PAHs														
Benzo(a)anthracene		120	30	76	110	1600	110	370	220	30	280	110	1600	277.8
Benzo(a)pyrene		200	70	190	280	1800	96	440	240	41	310	150	1800	347.0
Benzo(b)fluoranthene		620	66	190	570	1800	130	510	290	57	370	180	1800	434.8
Benzo(g,h,i)perylene		120	51	94	1200	790	170	320	180	40	210	110	1200	298.6
Benzo(k)fluoranthene		110	33	85	240	1100	46	220	120	21	150	78	1100	200.3
Chrysene		180	53	110	120	1900	85	210	180	32	180	86	1900	285.1
Dibenz(a,h)anthracene		24	20	34.5	100	235	14	42	32	4.8	32	16	235	50.4
Fluoranthene		240	48	210	110	3600	200	1000	500	77	560	300	3600	622.3
Indeno(1,2,3-c,d)pyrene		83	38	130	670	750	65	180	93	18	120	62	750	200.8
Pyrene		220	43	150	81	3100	160	820	400	64	480	240	3100	523.5
Total High Molecular Weight PAHs														
Total PAHs		2566	928	2170	3872.1	27530	1776.55	7210.5	3880.5	680.8	4186	2377.5	27530	5198.0
Metals (mg/kg)														
Aluminum		9370	6860	7340	4050	8160	4200	2440	3950	4650	11400	4790	11400	6110.0
Antimony		0.095	0.090	0.84	3.2	0.090	1.8	1	2	1.4	1.2	1.9	3.2	1.2
Arsenic (total)		2.4	2.5	5.9	9.6	3.4	2.5	15.1	16.2	3.6	4.8	3.9	16.2	6.4
Barium		37.5	21.4	66.7	99.6	50	53.9	87.6	64.7	76.6	53.4	46.2	99.6	59.8
Beryllium		0.35	0.36	0.33	0.32	0.43	0.26	0.33	0.3	0.37	0.43	0.37	0.43	0.35
Cadmium		0.13	0.12	0.19	2.4	0.12	0.31	0.52	1	0.35	2.4	6	6.0	1.2
Calcium		46700	884	1830	1270	31200	1210	3760	1040	706	1110	672	46700	8216.5
Chromium (total)		12.9	13.7	11.4	15.4	12.6	8	5.5	11.6	11.9	19.7	12.2	19.7	12.3
Cobalt		6.1	5.3	7.1	4.9	5.4	4.4	2	6.2	3.1	6.9	6.2	7.1	5.2
Copper		6.9	11.8	38.7	37.1	12.6	17.9	4.6	242	24.5	14.1	42.1	242	41.1
Iron		19000	11900	11100	16600	14100	10500	5870	12100	12700	22500	10100	22500	13315.5
Lead		8.7	27.9	74.9	181	52.1	54.6	60.8	133	67.1	44.5	136	181	76.4
Magnesium		3680	1680	735	738	4250	523	566	468	445	1110	472	4250	1333.4
Manganese		340	235	363	226	215	253	53.7	307	180	152	151	363	225.1
Mercury		0.05	0.02	0.44	0.4	0.05	0.030	0.21	0.16	0.22	0.19	2.9	2.9	0.4
Nickel		10.3	8.8	20.5	11.7	9	5.1	9.5	6.2	7.2	11.2	20.6	20.6	10.9
Potassium		413	830	445	212	750	234	183	211	104	371	171	830	356.7
Selenium		0.12	0.11	1.6	3.3	0.26	0.91	1.4	0.87	0.88	1.5	1.1	3.3	1.1
Silver		0.23	0.21	1.5	0.055	0.22	0.055	0.060	0.050	0.055	0.060	0.055	1.5	0.2
Sodium		37.7	21	57.3	98.4	60.9	92.6	159	77.5	89.8	98	106	159	81.7
Thallium		0.18	0.17	0.27	0.46	0.46	0.055	0.060	0.055	0.055	0.24	0.055	0.46	0.2
Vanadium		14.2	15.9	19.5	21.2	19.3	24.9	12.4	20.9	21.4	44.5	19	44.5	21.2
Zinc		23.2	34.9	147	286	43.9	105	180	158	59.8	149	450	450	148.8

Table 4. Open salvage/storage yard (AOC 2) with "hotspots" removed vs. soil benchmarks

data without sites 4, 6, 7, 14 and 15 (hotspots)									
Contaminant	Soil	Soil	Benchmark	Reference	Hazard	Hazard	CCME	ORNL	HQ Max
	Max.	Mean		Source	Quotient	Quotient	Bench	Bench	CCME
	Conc.	Conc.			with Max	with Mean			ORNL
Low Molecular Weight PAHs									
2-methylnaphthalene	NA		NB	NB					
Acenaphthene	1700	603.2		100 x - fauna	17	6.0			
Acenaphthylene	4250	491.8		100 x - fauna	42.5	4.9			
Anthracene	770	114.5		100 x - fauna	7.7	1.1			
Fluorene	235	41.3		100 x - fauna	2.35	0.4			
Naphthalene	1200	217.0		100 x - fauna	12	2.2			
Phenanthrene	3200	489.7		100 x - fauna	32	4.9			
Total Low Molecular Weight PAHs			NB	NB					
High Molecular Weight PAHs									
Benzo(a)anthracene	1600	277.8		100 x - fauna	16	2.8			
Benzo(a)pyrene	1800	347.0		100 x - fauna	18	3.5			
Benzo(b)fluoranthene	1800	434.8		100 x - fauna	18	4.3			
Benzo(g,h,i)perylene	1200	298.6		100 x - fauna	12	3.0			
Benzo(k)fluoranthene	1100	200.3		100 x - fauna	11	2.0			
Chrysene	1900	285.1		100 x - fauna	19	2.9			
Dibenz(a,h)anthracene	235	50.4		100 x - fauna	2.35	0.5			
Fluoranthene	3600	622.3		100 x - fauna	36	6.2			
Indeno(1,2,3-c,d)pyrene	750	200.8		100 x - fauna	7.5	2.0			
Pyrene	3100	523.5		100 x - fauna	31	5.2			
Total High Molecular Weight PAHs			NB	NB					
Total PAHs	27530	5198.0	NB	NB					
Metals (mg/kg)									
Aluminum	11400	6110.0	1	x - flora	11400.00	6110.0	NB	600	
Antimony	3.2	1.7	0.48	x - flora	6.67	3.5	NB	NB	
Arsenic (total)	16.2	6.4	328	x - flora	0.05	0.0	19	100	0.85
Barium	99.6	59.8	440	x - fauna	0.23	0.1	NB	3000	0.03
Beryllium	0.43	0.4	0.02	x - flora	21.50	17.5	NB	NB	
Cadmium	6	1.2	2.5	x - flora	2.40	0.5	3.8	20	1.58
Calcium	46700	8216.5	NB	NB			NB	NB	
Chromium (total)	19.7	12.3	0.0075	x - fauna	2626.67	1635.2	64	0.4	0.31
Cobalt	7.1	5.2	100	x - flora	0.07	0.1	NB	1000	0.01
Copper	242	41.1	15	x - flora	16.13	2.7	63	50	3.84
Cyanide	NA		0.005	x - fauna			NA		
Iron	22500	13315.5	12	x - fauna	1875.00	1109.6	NB	200	
Lead	181	76.4	0.01	x - fauna	18100.00	7641.8	70	500	2.59
Magnesium	4250	1333.4	4400	x - fauna	0.97	0.3	NB	NB	
Manganese	363	225.1	330	x - fauna	1.10	0.7	NB	100	
Mercury	2.9	0.4	0.058	x - fauna	50.00	6.9	10	0.1	0.29
Nickel	20.6	10.9	2	x - flora	10.30	5.5	NB	200	0.10
Potassium	830	356.7	NB	NB			NB	NB	
Selenium	3.3	1.3	1.8	x - fauna	1.83	0.7	NB	70	0.05
Silver	1.5	1.5	0.0000098	x - flora	153061.22	153061.2	NB	50	0.03
Sodium	159	81.7	NB	NB			NB	NB	
Thallium	0.46	0.4	0.001	x - flora	460.00	386.7	NB	NB	
Vanadium	44.5	21.2	0.5	x - flora	89.00	42.4	130	20	0.34
Zinc	450	148.8	10	x - flora	45.00	14.9	200	100	2.25
									4.50
NB = No benchmark									
NA = Not Applicable									
x-fauna= Region III BTAG Screening level for fauna (lowest of flora and fauna)									
x-flora= Region III BTAG Screening level for flora (lowest of flora and fauna)									
CCME Bench. = Canadian Soil Quality Guidelines									
ORNL Bench. = Efroyimson et al. 1997									
HQ Max CCME = Maximum soil concentration divided by the Canadian soil guidelines									
HQ Max ORNL = Maximum soil concentration divided by the ORNL Benchmark									